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## Ohio Field Office Recycled Uranium Project Report

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## EXECUTIVE SUMMARY

### Introduction

This document addresses the historical generation and flow of recycled uranium in the DOE complex for four facilities, the Fernald Environmental Management Project (FEMP), the RMI Environmental Services site (RMI), the West Valley Demonstration Project (WVDP), and the Weldon Spring Site Remedial Action Project (WSSRAP). Each of these sites was identified in the February 2000 Historical Generation and Flow of Recycled Uranium in the DOE Complex as either Tier 1 or Tier 2 sites. In order to quantify and evaluate the potential flow of recycled uranium and its constituents of concern to and from these facilities, the efforts of the DOE Ohio Field Office Recycled Uranium Project Report team focused on the identification, collection, and review of receipt and shipment data. Since the recycle of irradiated uranium began in the 1950s, a significant portion of the desired data was generated 40+ years ago and even pre-dates the implementation of the current Nuclear Materials Management and Safeguards System (NMMSS). In addition, much of the data and records generated during the sites' production years were closely controlled due to national security and classification requirements that were designed to reinforce a "need to know" environment. As such, recent searches of previously classified historical data have resulted in the identification of data gaps and/or less than complete records for the receipt and shipment of uranium materials within the complex. These gaps appear to have resulted from the destruction of classified information in lieu of declassifying the data. Furthermore, the "need to know" environment also is a probable contributor to difficulties encountered in attempting to reconstruct information, based on the knowledge of former site workers since these individuals, in most instances, only dealt with information and data for their work area or facility. The DOE Ohio Field Office team has conscientiously attempted to research and obtain historical information and data for use in the development of this report and the following data and analysis represents the best available information concerning the receipt, processing, and shipment of recycled uranium for the four facilities.

### Summary Conclusion

The following tables, Table ES-1 (A-D) summarize the conclusions and information presented in this document. The convention used throughout this document is to breakout the assaying of uranium into enriched, depleted, and normal streams. A second convention in the document is that Table A is for FEMP information and data. Table B is for RMI information and data. Table C is for WVDP information and data. Table D is for WSSRA project information and data. Receipts are discussed before shipments.



**TABLE ES-1A**  
**FEMP SUMMARY OF CALCULATED CONSTITUENT MASSES**  
**FOR RECEIPTS/SHIPMENTS/INVENTORY OF RECYCLED URANIUM**

Isotopic Range	Total U (MTU)	RU Quantity (MTU)	Calculated Constituent Mass (Grams)		
			Pu-239	Np-237	Tc-99
Enriched – Receipts	64,939.4	60,180.7	207.9	19,047.5	328,740.2
Normal – Receipts	193,156.5	89,649.2	4.1	3,025.9	1,197.4
Depleted – Receipts	105,485.9	96,853.2	5.7	3,668.7	2,060.5
<b>Total – Receipts</b>	<b>363,581.8</b>	<b>246,683.1</b>	<b>217.7</b>	<b>25,742.1</b>	<b>331,998.1</b>
Enriched – Shipments	64,144.1	60,305.6	180.9	20,769.3	333,698.9
Normal – Shipments	193,047.7	94,852.8	7.7	5,683.8	2,249.3
Depleted – Shipments	102,678.4	94,071.1	2.4	424.8	1,541.3
<b>Total – Shipments</b>	<b>359,870.2</b>	<b>249,229.5</b>	<b>191.0</b>	<b>26,877.9</b>	<b>337,489.5</b>
Enriched – NM Inventory	801.3	801.3	14.4	531.1	1,858.4
Normal – NM Inventory	193.4	193.4	0.7	84.2	308.9
Depleted – NM Inventory	2,807.1	2,807.1	<0.1	13.0	5.1
<b>Total – NM Inventory</b>	<b>3,801.8</b>	<b>3,801.8</b>	<b>15.2</b>	<b>628.3</b>	<b>2,172.4</b>
Enriched – Waste Inventory	430.6	430.6	7.3	345.1	1,870.2
Normal – Waste Inventory	13.2	13.2	<0.1	0.9	0.4
Depleted – Waste Inventory	867	867	0.1	13.7	50.3
<b>Total – Waste Inventory</b>	<b>1,310.8</b>	<b>1,310.8</b>	<b>7.5</b>	<b>359.7</b>	<b>1,920.9</b>

**TABLE ES-1B**  
**RMI SUMMARY OF CALCULATED CONSTITUENT MASSES**  
**FOR RECEIPTS/SHIPMENTS/INVENTORY**

Isotopic Range	Total U (MTU)	RU Quantity (MTU)	Calculated Constituent Mass (Grams)		
			Pu-239	Np-237	Tc-99
Enriched – Receipts	25,327.4	25,327.4	108.8	9,422.6	178,542.0
Normal – Receipts	5,236.0	5,236.0	0.5	351.3	139.0
Depleted – Receipts	46,158.5	46,158.5	0.3	117.2	421.0
<b>Total – Receipts</b>	<b>76,721.9</b>	<b>76,721.9</b>	<b>109.6</b>	<b>9,891.1</b>	<b>179,102.0</b>
Enriched – Shipments	25,269.8	25,269.8	108.6	9,401.1	178,135.9
Normal – Shipments	5,181.8	5,181.8	0.5	347.6	137.6
Depleted – Shipments	45,722.7	45,722.7	0.1	25.0	89.9
<b>Total – Shipments</b>	<b>76,174.3</b>	<b>76,174.3</b>	<b>109.2</b>	<b>9,773.7</b>	<b>178,363.4</b>
<b>Total – NM Inventory</b>	<b>--</b>	<b>--</b>	<b>--</b>	<b>--</b>	<b>--</b>
<b>Total – Waste Inventory</b>	<b>--</b>	<b>--</b>	<b>--</b>	<b>--</b>	<b>--</b>





**TABLE ES-1C**  
**WVDP SUMMARY OF CALCULATED CONSTITUENT MASSES**  
**FOR RECEIPTS/SHIPMENTS/INVENTORY**

Isotopic Range	Total U (MTU)	RU Quantity (MTU)	Calculated Constituent Mass (Grams)		
			Pu-239	Np-237	Tc-99
Enriched – Receipts	--	--	--	--	--
Normal – Receipts	--	--	--	--	--
Depleted – Receipts	--	--	--	--	--
<b>Total – Receipts</b>	--	--	--	--	--
Enriched – Shipments	464.4	464.4	1.8	64.6	1,465.2
Normal – Shipments	12.9	12.9	0.1	1.8	40.7
Depleted – Shipments	142.1	142.1	0.6	19.8	448.3
<b>Total – Shipments</b>	<b>619.4</b>	<b>619.4</b>	<b>2.5</b>	<b>86.2</b>	<b>1,954.2</b>
<b>Total – NM Inventory</b>	--	--	--	--	--
<b>Total – Waste Inventory</b>	--	--	--	--	--

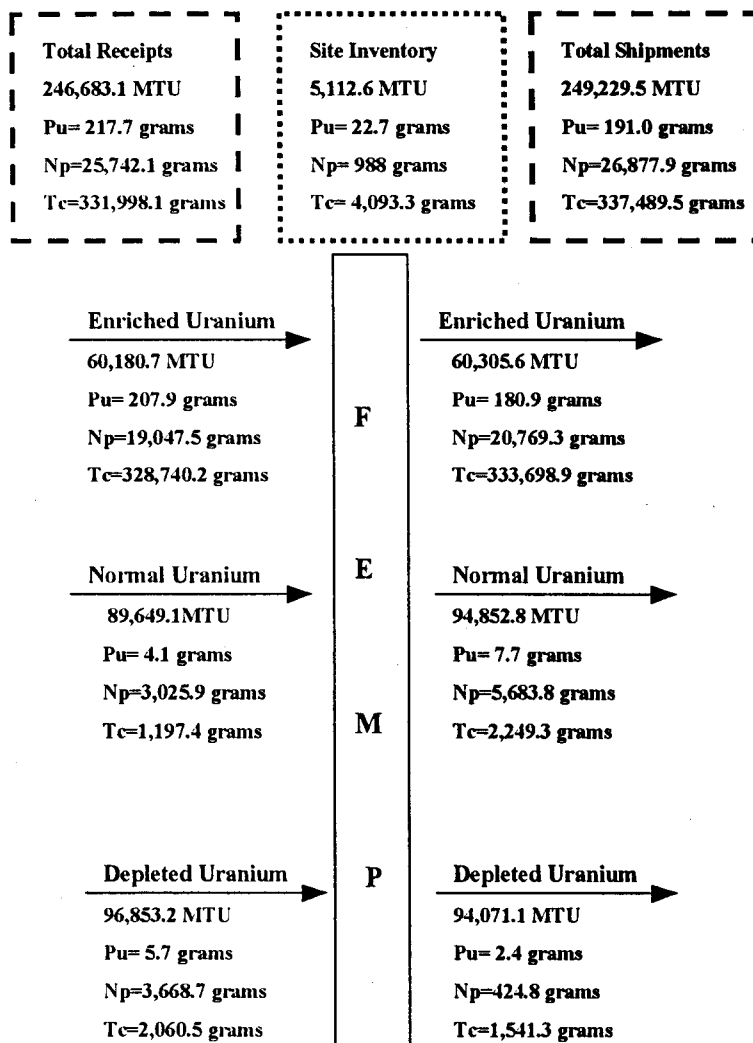
**TABLE ES-1D**  
**WSSRAP SUMMARY OF CALCULATED CONSTITUENT MASSES**  
**FOR RECEIPTS/SHIPMENTS/INVENTORY**

Isotopic Range	Total U (MTU)	RU Quantity (MTU)	Calculated Constituent Mass (Grams)		
			Pu-239	Np-237	Tc-99
Enriched – Receipts	842.6	842.6	2.4	327.7	7,206.1
Normal (Natural) – Receipts	122,015.9	70,538.4	--	--	--
Depleted – Receipts	167.8	32.0	0	0.1	0.3
<b>Total – Receipts</b>	<b>123,026.3</b>	<b>71,413.0</b>	<b>2.4</b>	<b>327.8</b>	<b>7,206.4</b>
Enriched – Shipments	833.9	833.9	2.4	324.4	7,131.7
Normal (Natural)– Shipments	121,901.2	73,878.4	--	--	--
Depleted – Shipments	167.8	92.3	0	0.2	0.8
<b>Total – Shipments</b>	<b>122,902.9</b>	<b>74,804.6</b>	<b>2.4</b>	<b>324.6</b>	<b>7,132.5</b>
<b>Total – NM Inventory</b>	--	--	--	--	--
<b>Total – Waste Inventory</b>	--	--	--	--	--

The following figures ES-1 (A-D) show a graphical presentation of the receipts and shipments of recycled uranium for the sites included in this report. The additional non-recycled uranium received and processed by the sites has not been included in these figures.



**FIGURE ES-1A  
FEMP RECYCLED  
URANIUM MASS BALANCE**





**FIGURE ES-1B  
RMI RECYCLED URANIUM MASS  
BALANCE**

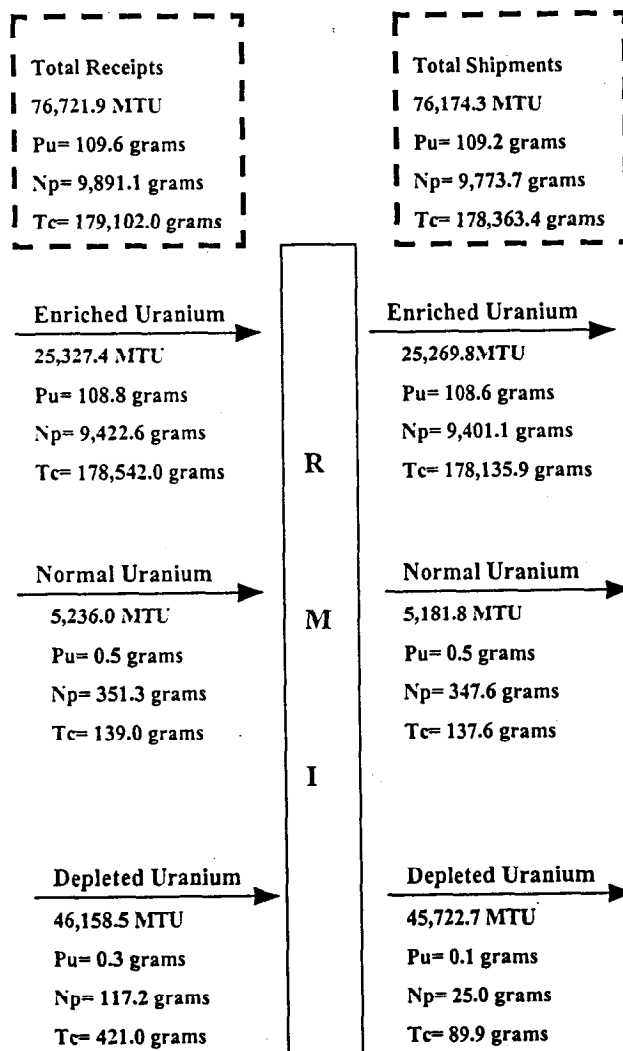
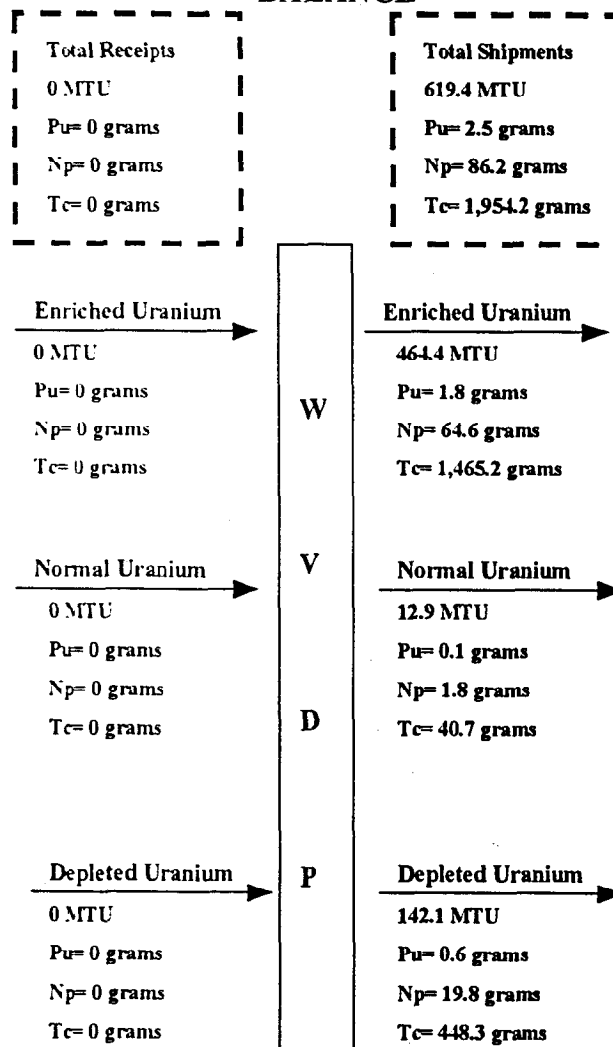


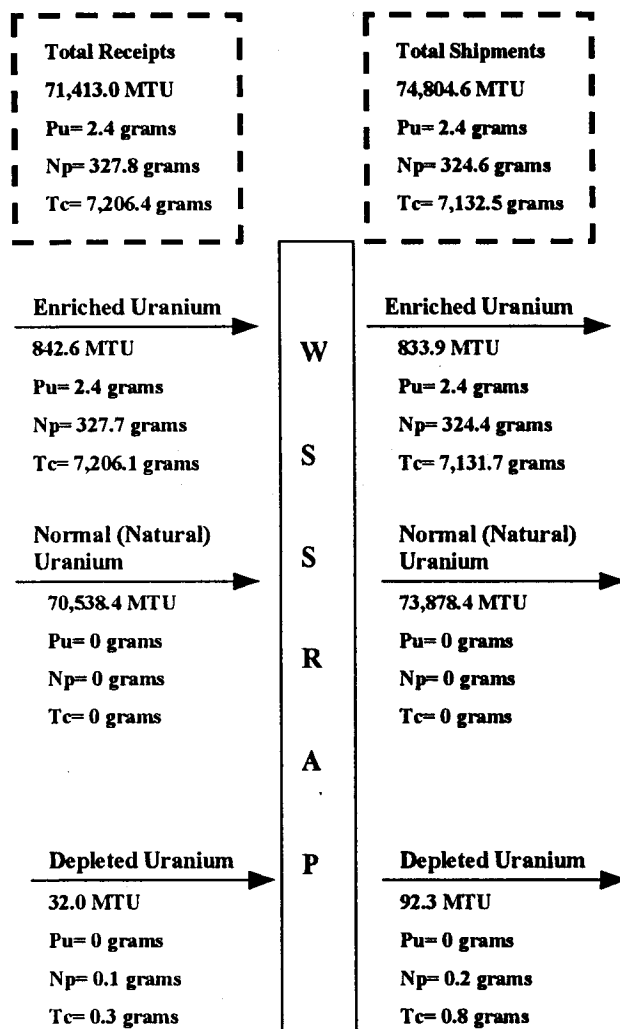


FIGURE ES-1C  
WVDP RECYCLED URANIUM MASS  
BALANCE





**FIGURE ES-1D  
WSSRAP RECYCLED URANIUM MASS  
BALANCE**





## **Document Description**

This document, prepared by the DOE Ohio Field Office, compiles data and discusses the flow of recycled uranium and transuranic/fission product constituents that occurred during the operational history of four uranium processing facilities. These facilities include the FEMP, the RMI, WVDP and WSSRAP. This report addresses historical flows of recycled uranium between these facilities, other DOE and predecessor agencies, sites, and other nuclear facilities.

## **Site Descriptions**

The FEMP is a 1050-acre site located in southwestern Ohio, approximately 20 miles northwest of downtown Cincinnati, near the communities of Fernald, Miamitown and Ross. The FEMP, formerly known as the Feed Materials Production Center, is owned by the U.S. Department of Energy. Production operations were active from 1952 through 1989. During this period, the FEMP supported U.S. DOE Defense Programs (DP) missions at Hanford, Savannah River, Oak Ridge Y-12 Plant, and Rocky Flats by producing various uranium products at standard enrichment assays. The FEMP was built by the United States Atomic Energy Commission (AEC) to establish an in-house integrated production complex for processing uranium and its compounds from natural uranium ore concentrates and recycled uranium residues. A wide variety of chemical and metallurgical process steps have been utilized to support the manufacturing of high-purity uranium metal products. Throughout its lifetime, the FEMP received in excess of 246,000 metric tons uranium (MTU) of recycled uranium and shipped in excess of 249,000 MTU of recycled uranium. Since the curtailment of production operations in 1989, the FEMP has been focused on the investigation and clean-up of the site under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). A map of the site is included in Appendix H.4.

The RMI site is located on the northern edge of Ashtabula County, slightly east of the City of Ashtabula, Ohio. The facility consists of 23 buildings on approximately 32 acres. Beginning in 1962, the primary function of RMI was to extrude slightly enriched, normal, and depleted uranium metal for the DOE. The uranium was extruded into rods, tubes, and other shapes as an intermediate step in the production of nuclear fuel elements at other DOE sites. The extrusion of uranium for the DOE ceased at RMI in September 1988. During its 26 years of operations, RMI received and shipped approximately 76,100 MTU of recycled uranium. Since the cessation of extrusion operations in 1988, the RMI site has been focusing on activities necessary to decommission the site for unrestricted use. A map of the site is included in Appendix H.4.



The WVDP is located in Cattaraugus County approximately 35 miles south of Buffalo, New York. The WVDP, formerly referred to as the Nuclear Fuel Services West Valley facility, operated as a private spent nuclear fuel reprocessing center from 1965 through 1972 using the Plutonium Uranium Extraction (PUREX) process. Throughout its operational history, West Valley received both commercial and government spent fuels, with roughly 60 percent of the fuel and 33 percent of the plutonium coming from DOE reactors. As a spent fuel processing facility, WVDP is a source site and, therefore, did not receive recycled uranium. It did however, reprocess and recover approximately 620 MTU of recycled uranium and ship the recovered uranium to the FEMP for conversion into metal and intermediate uranium compounds. Since the passage of the West Valley Demonstration Project Act (WVDPA) in 1980, the DOE and its site contractors have been involved in the solidification of high level radioactive wastes and the decontamination and decommissioning of the facility. A map of the site is included in Appendix H.4.

The WSSRAP consists of approximately 205 acres and is located in St. Charles County, Missouri. The WSSRAP originally was operated by the Mallinckrodt Chemical Works as a feed materials plant for processing uranium and thorium ore concentrates, similar to the processes at the FEMP. During operations, the plant processed uranium metal; intermediate forms including uranium dioxide, uranium trioxide and uranium tetrafluoride. The WSSRAP received and shipped over 71,400 MTU during its operating history. The facility was shutdown in 1968. The WSSRAP has completed extensive remediation including the establishment of an onsite disposal facility since being placed on the National Priority List in the late 1980's. A map of the site is included in Appendix H.4.

### **Summary Uranium Flow**

Summary uranium flow is represented in the following table for each of the four sites, with all receipts totaled since 1952. The recycle uranium is a sub-total in that the receipts and shipments started in 1962. Based on this information approximately 64% of the receipts at the FEMP. WSSRAP received 58% of its uranium during the recycle uranium timeframes, however, the site literature indicates all normal uranium was actually natural uranium.



**Table ES-2**  
**Summary of Facility Receipts and Shipments**

<b>Facility</b>	<b>All Receipts (MTU)</b>	<b>Recycle Receipts (MTU)</b>	<b>All Shipments (MTU)</b>	<b>Recycle Shipments (MTU)</b>
<b>FEMP</b>				
Enriched U	64,939.4	60,180.7	64,144.1	60,305.6
Normal U	193,156.5	189,649.2	193,047.7	94,852.8
Depleted U	105,485.9	96853.2	102,678.4	94,071.1
<b>Total</b>	<b>363,581.8</b>	<b>246,683.1</b>	<b>359,870.2</b>	<b>249,229.5</b>
<b>RMI</b>				
Enriched U	25,327.4	25,327.4	25,269.8	25,269.8
Normal U	5,236.0	5,236.0	5,181.8	5,181.8
Depleted U	46,158.5	46,158.5	45,722.4	45,722.4
<b>Total</b>	<b>76,721.9</b>	<b>76,721.9</b>	<b>76,174.4</b>	<b>76,174.4</b>
<b>WVDP</b>				
Enriched U	--	--	464.4	464.4
Normal U	--	--	12.9	12.9
Depleted U	--	--	142.1	142.1
<b>Total</b>	<b>--</b>	<b>--</b>	<b>619.4</b>	<b>619.4</b>
<b>WSSRAP</b>				
Enriched U	842.6	842.6	833.9	833.9
Normal (Natural) U	122,015.9	70,538.4	121,901.2	73,878.4
Depleted U	167.8	32.0	167.8	92.3
<b>Total</b>	<b>123,026.3</b>	<b>71,413.0</b>	<b>122,902.9</b>	<b>74,804.6</b>

#### **Concentration/Removal Activities**

The FEMP, RMI, and WSSRAP routinely received recycled uranium metal and compounds with trace quantities of transuranic constituent content as for reuse in support of DOE Defense Programs. Except for a limited number of specific material receipts, the uranium materials received at the FEMP contained transuranics and other recycle constituents at levels below a concern for significant radiation exposure impacts. Because these constituents could possibly be concentrated in FEMP chemical processes, a review of these processes was performed during the development of this report.

The following table, ES-3 A provides a summary of the processes which represent where the constituents would be found, in terms relative to the feed materials. This information is discussed in greater detail in Section 2.4 of this document. There was no information to prepare tables for the other three sites.





**TABLE ES-3A**  
**FEMP PROCESSES/ACTIVITIES THAT CONCENTRATED CONSTITUENTS**

Process Step/Activity	Explanation
Extraction	87.2 percent initial fed Pu and 41.6 percent initial fed Np reports to the UO <sub>3</sub> product stream
UF <sub>6</sub> to UF <sub>4</sub>	Concentration in heel of constituents
Hydrofluorination	Potential Tc vaporization
Reduction	46 percent Pu and 63 percent Np reports to MgF <sub>2</sub> Slag
Vacuum Casting	5 percent Pu and 64 percent Np reports to crucible and mold residues
Metal Pickling	Surface residues (higher in Pu and Np) dissolve in pickling acid
Machining	Top Crops greater than metal product in feed
Scrap Recovery Operations	Handles residues from many of the concentrating processes

The remaining sites in this report were not identified in Section 2.4 to be expected of concentrating recycle constituents to any significant degree.

### **Recycle Uranium Shipments**

Table ES-1 (A-D) shows the highest summary level of the uranium flow. The major facilities that shipped or received materials depicted include the following : Oak Ridge (K-25), Oak Ridge (Y-12), Portsmouth, Paducah, RMI, West Valley, Weldon Spring, Hanford, Savannah River, Rocky Flats, Idaho, and Other Sites. This convention is used throughout the tables in this Section and throughout the Appendices A (Receipts) and B (Shipments).

Table ES-4 (A-D) details the receipts and shipments at these various facilities subdivided into enriched, normal, and depleted materials. Figures ES-2 (A-D) are graphical representations of the total recycled uranium receipts and shipments by facility along with the corresponding constituent mass balance. These figures show a summary level by rounding off of the amounts (reduced number of significant figures). The constituent mass balance numbers are taken from Appendix F, starting with Table F.5-1A.



**TABLE ES-4A**  
**FEMP RECEIPTS AND SHIPMENTS OF RECYCLED URANIUM (1962-1989)**

Facility/Location	Enriched Receipts	Enriched Shipments	Normal Receipts	Normal Shipments	Depleted Receipts	Depleted Shipments
Oak Ridge (K-25)	1,062.2	4.0	246.1	13.4	1,413.3	0.3
Oak Ridge (Y-12)	88.1	31.7	18.4	108.0	21.4	9,390.5
Portsmouth	1,172.8	145.9	541.4	701.3	<0.1	1.2
Paducah	7,696.7	7,219.8	131.1	25,914.2	51,872.8	3,554.8
RMI	17,136.5	26,210.6	4,997.7	5,235.6	35,678.7	35,875.3
West Valley	466.2	--	12.9	<0.1	142.1	--
Weldon Spring	810.9	837.5	44,547.4	10,133.3	5.1	2.8
Hanford	19,652.3	17,467.5	2,635.1	30,788.3	481.7	125.2
Savannah River	3,423.8	3,971.2	1,298.7	3,982.8	1,669.7	24,193.6
Rocky Flats	1.3	2.1	4.0	<0.1	1,318.2	5,352.5
Idaho	1.6	--	<0.1	0.5	0.3	83.9
Other Sites	8,668.3	4,415.3	35,217.4	17,975.4	4,249.8	15,491.0
<b>Total</b>	<b>60,180.7</b>	<b>60,305.6</b>	<b>89,649.2</b>	<b>94,852.8</b>	<b>96,853.2</b>	<b>94,071.1</b>

**TABLE ES-4B**  
**RMI RECEIPTS AND SHIPMENTS OF RECYCLED URANIUM (1962-1989)**

Facility/Location	Enriched Receipts	Enriched Shipments	Normal Receipts	Normal Shipments	Depleted Receipts	Depleted Shipments
Oak Ridge (Y-12)	--	--	--	--	240.3	224.2
Paducah	--	--	--	--	--	3.0
FEMP	25,214.9	15,973.3	5,235.6	4,970.2	35,878.7	35,855.7
WSSRAP	--	--	--	2.2	--	--
Hanford	112.5	9,296.3	0.4	209.4	--	12.4
Savannah River	--	--	--	--	<0.1	<0.1
Rocky Flats	--	--	--	--	9	8.8
Other Sites	--	0.2	<0.1	<0.1	10,030.5	9,618.5
<b>Total</b>	<b>25,327.4</b>	<b>25,269.8</b>	<b>5,236.0</b>	<b>5,181.8</b>	<b>46,158.5</b>	<b>45,722.7</b>



FIGURE ES-2A.1  
FEMP SUMMARY RECYCLED URANIUM MASS BALANCE - RECEIPTS

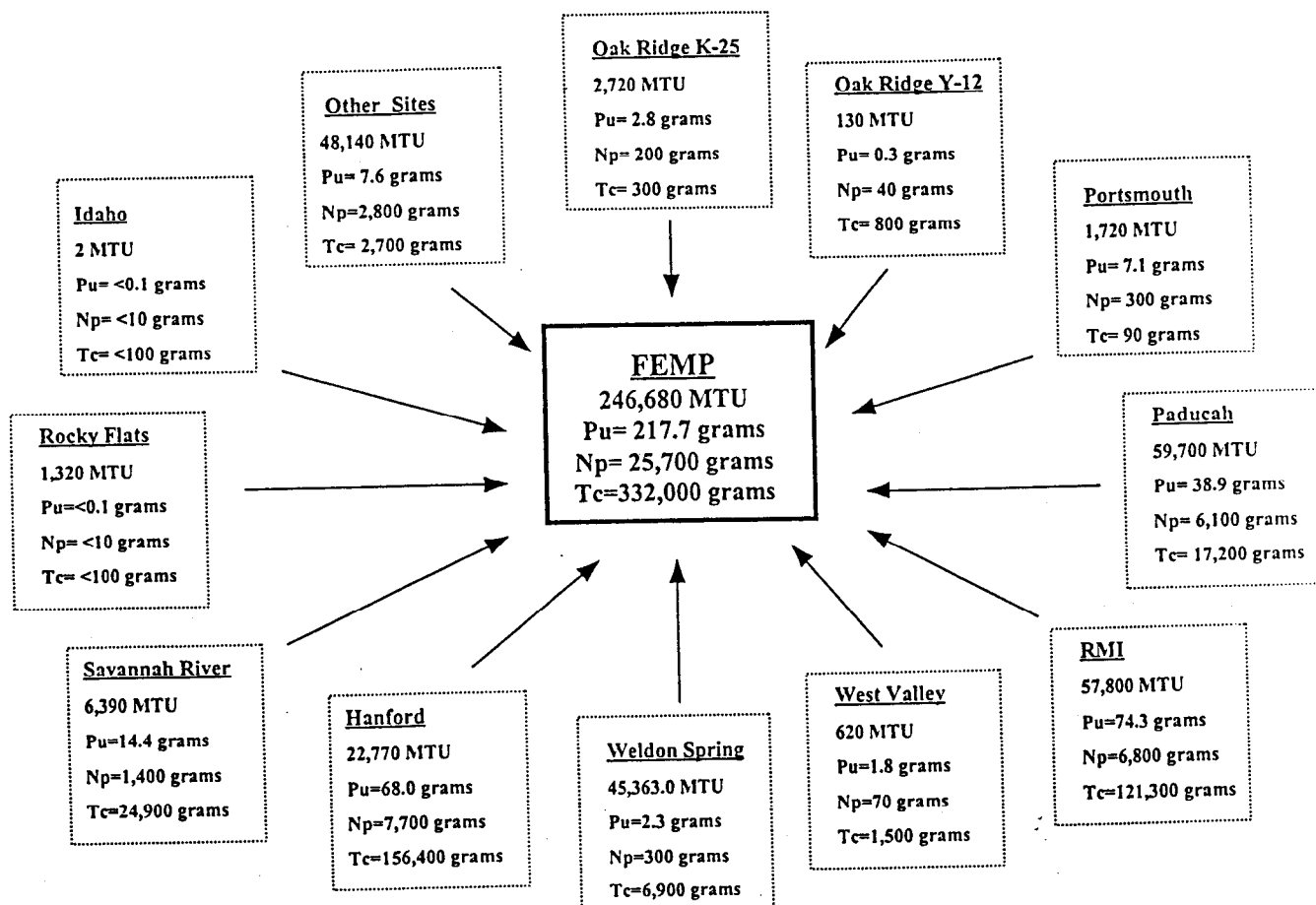




FIGURE ES-2A.2  
FEMP SUMMARY RECYCLED URANIUM MASS BALANCE - SHIPMENTS

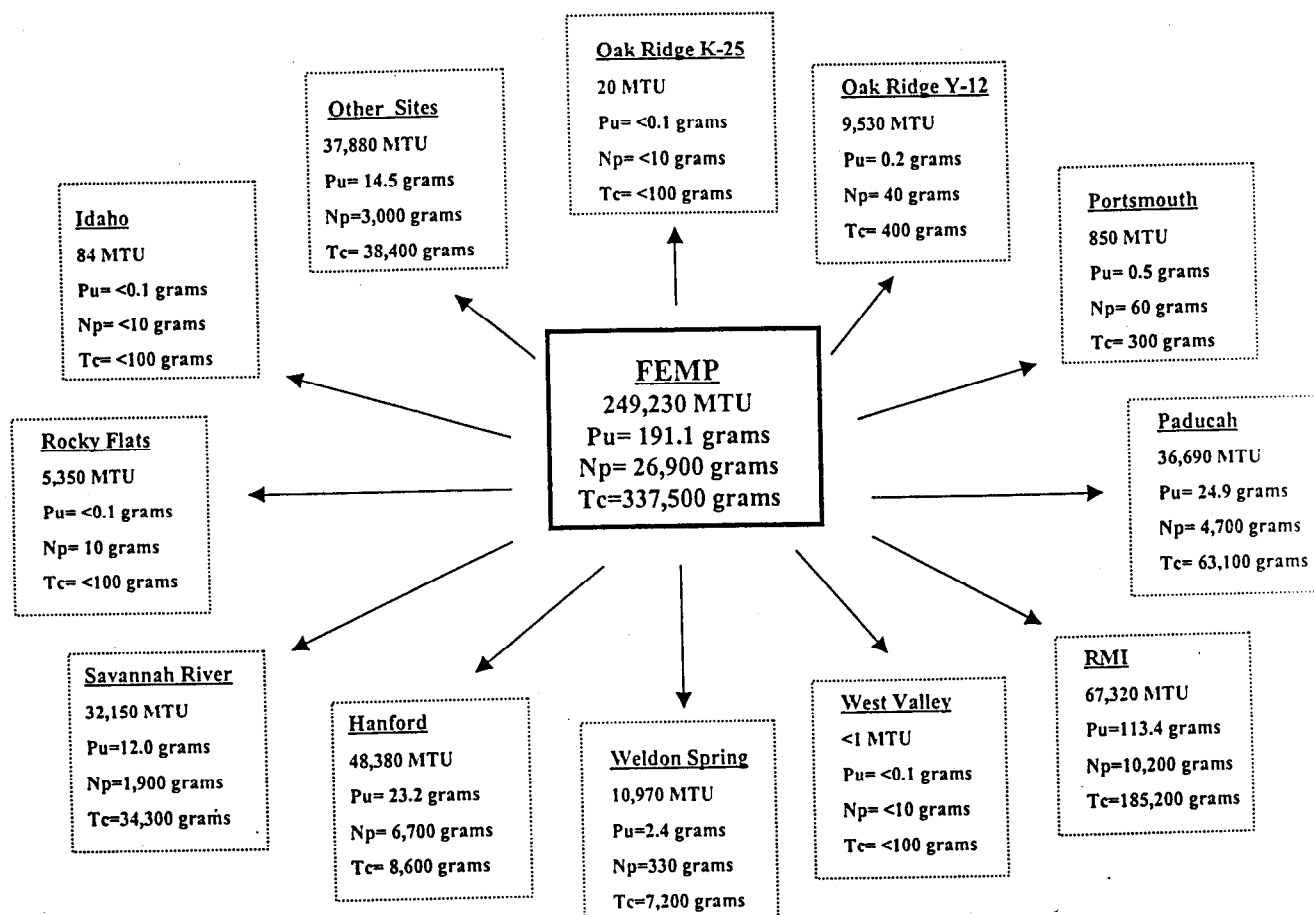




FIGURE ES-2B

RMI SUMMARY RECYCLED URANIUM MASS BALANCE - RECEIPTS AND SHIPMENTS

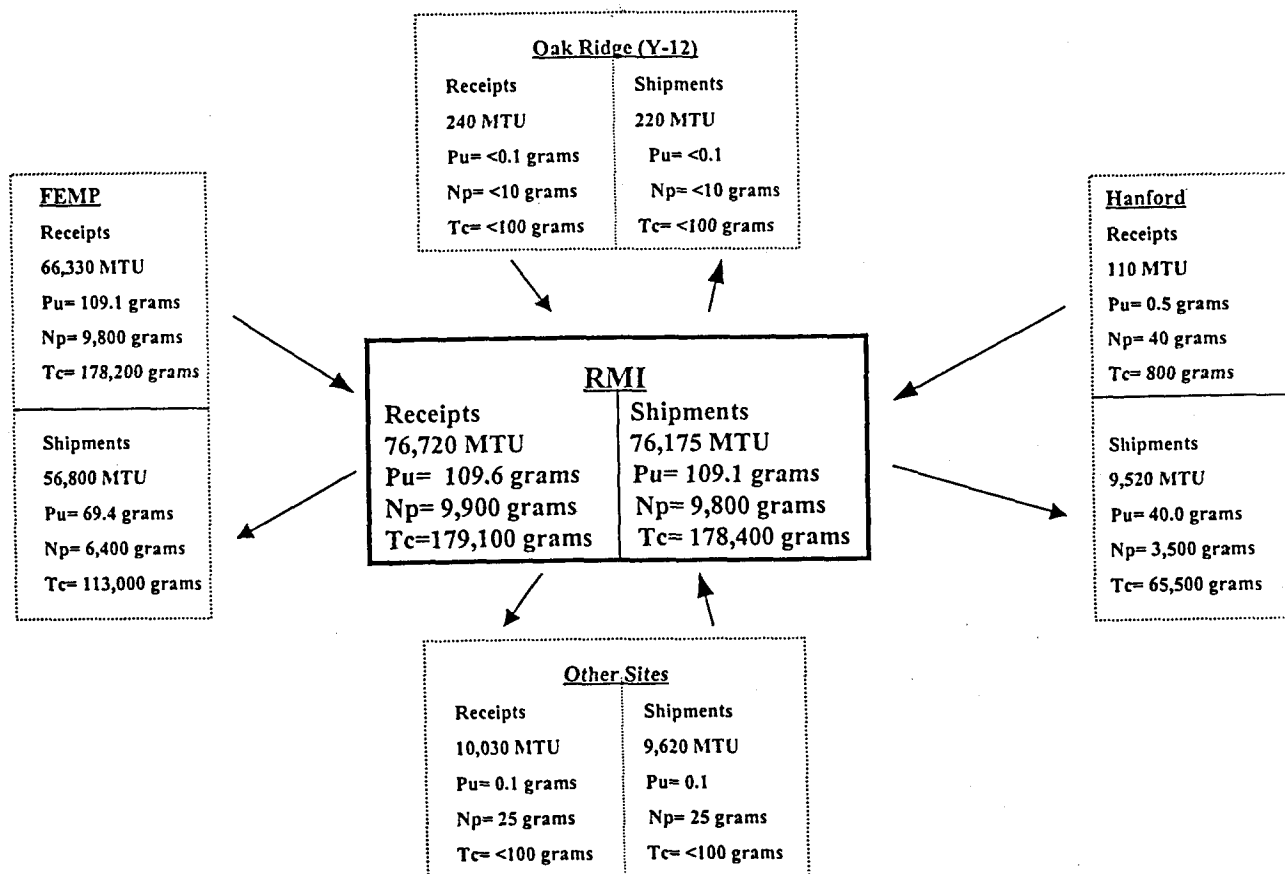




FIGURE ES-2C  
WVDP SUMMARY RECYCLED URANIUM MASS BALANCE - RECEIPTS AND SHIPMENTS

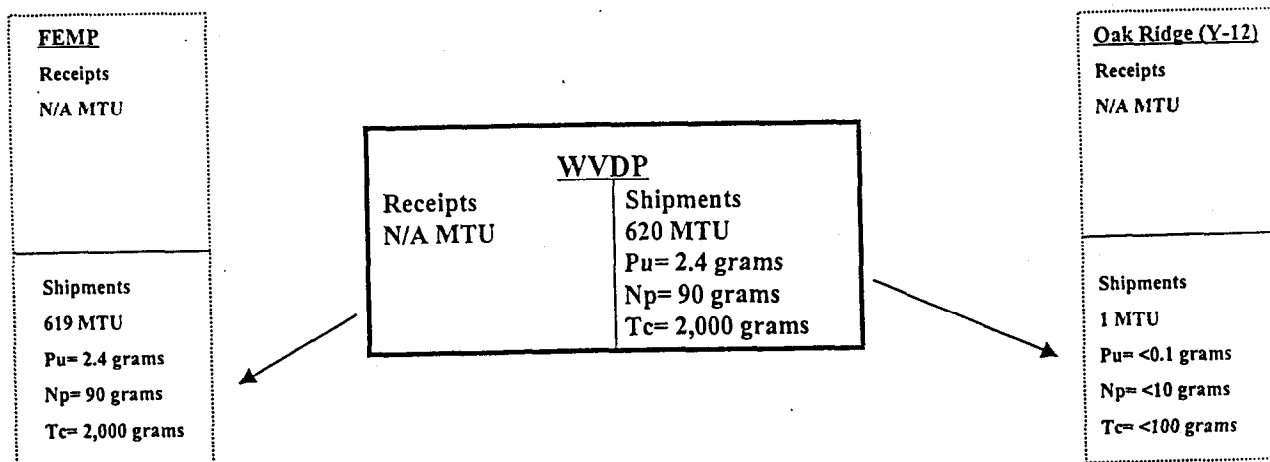
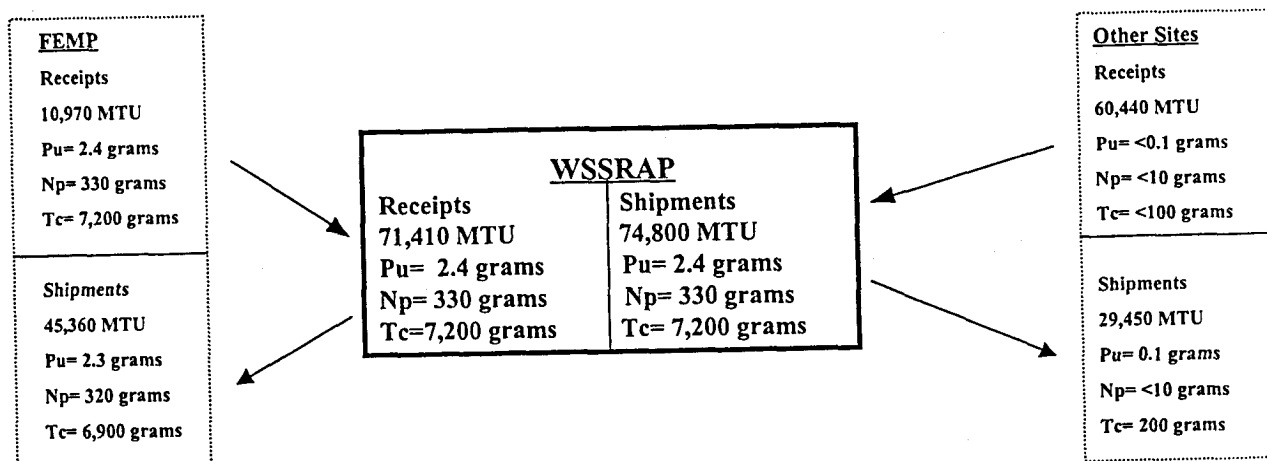




FIGURE ES-2D  
WSSRAP SUMMARY RECYCLED URANIUM MASS BALANCE - RECEIPTS AND SHIPMENTS





**TABLE ES-4C**  
**WVDP RECEIPTS AND SHIPMENTS OF RECYCLED URANIUM (1962-1989)**

Facility/Location	Enriched Receipts	Enriched Shipments	Normal Receipts	Normal Shipments	Depleted Receipts	Depleted Shipments
Oak Ridge (Y-12)	--	1.2	--	--	--	--
FEMP	--	463.2	--	12.9	--	142.1
<b>Total</b>	--	<b>464.4</b>	--	<b>12.9</b>	--	<b>142.1</b>

**TABLE ES-4D**  
**WSSRAP RECEIPTS AND SHIPMENTS OF RECYCLED URANIUM (1962-1989)**

Facility/Location	Enriched Receipts	Enriched Shipments	Normal Receipts	Normal Shipments	Depleted Receipts	Depleted Shipments
FEMP	837.5	810.8	10,133.3	44,547.4	2.8	5.1
Other Sites	5.1	23.1	60,405.1	29,331.0	29.2	87.2
<b>Total</b>	<b>842.6</b>	<b>833.9</b>	<b>70,538.4</b>	<b>73,878.4</b>	<b>32.0</b>	<b>92.3</b>

### Typical Impurities in Recycled Uranium

Two types of data are employed in developing this report. Initially, the mass of uranium shipped between sites is of interest. These data can be matched between shipper and receiver to bound the level of uncertainty or error. Shipper/Receiver Data are expressed in Metric Tons Uranium (MTU) and is presented by fiscal years for 1962 through 1999. In order to adequately assess the types and amounts of constituents in the uranium shipments and receipts, a second type of data is employed. This second data type is comprised of analytical laboratory data representing samples of various materials taken at the time of shipment/receipt or taken directly from production processes. The following sections further describe the data collection, qualification, and utilization for each of these two types of data.

The division of the analytical results dataset into sub-groupings was performed to categorize the data by process source attributes. These groupings were intended to segregate the data regimes for use in determining the recycle constituent flows associated with the uranium flows (shipper/receiver data). By creating what was postulated to be process/chemistry-based groupings, the project team intended that the separate regimes bounded by the sub-group definitions would be statistically evaluated to identify a representative value for the regime. This representative value would in turn be utilized to calculate constituent content in the mass flows of uranium between the sites.





**TABLE ES-5A**  
**FEMP REPRESENTATIVE CONSTITUENT VALUES BY DATA SUB-GROUP**

Sub-Group Number	Sub-Group (S/G) Title	Value for Pu-239 ppb U	Value for Np-237 ppb U	Value for Tc-99 ppb U
1A	Miscellaneous	16.035	1,328.11	2,399.22
1B	Miscellaneous – Minor Offsite	0.889	109.07	0.55
2	UF <sub>6</sub> Source UF <sub>4</sub> (GDP Tails)	0.502	54.90	201.61
3	UF <sub>6</sub> Source Metal & Scrap	0.007	2.54	9.12
4	Normal U Products, Res & Metal Scrap	0.091	67.09	26.55
5	Enriched UF <sub>6</sub> Source Products/Res.	1.259	81.39	2,109.61
6A	UO <sub>3</sub> PUREX Source (A508)(Unblended)	2.884	388.97	8,552.23
6B	A508 UO <sub>3</sub> /UF <sub>4</sub> & Res. (Low Cross)	2.321	332.94	8,934.58
6C	A508 UO <sub>3</sub> /UF <sub>4</sub> & Res. (High Cross)	23.969	1,045.29	2,789.56
6D	A500 Coded Enriched Residues	4.556	143.75	1,085.45
6E	SR UNH	16.527	--	--
6F	SR UO <sub>3</sub> – Not Shipped to FEMP	2.805	--	--
7A	A508 based Derbies	9.305	311.97	1,721.00
7B	A508 based Ingots & Metal	1.165	263.48	447.81
8	Enriched MgF <sub>2</sub>	96.618	1,881.53	1,651.23
9	Incinerator Ash & Scrap Res. From GDPs	47.616	3164.53	263.32
10A	Tower Ash & Decon Res.	412.177	10,503.53	2,618.36
10B	UO <sub>3</sub> from Tower Ash	20.772	498.17	2,405.28
11	Waste Residues <EDL	84.817	3,999.32	4,110.05

The statistical analysis was composed of the following steps:

- Review data Sub-Groups for duplicate records and other anomalies.
- Assess “less than” values to determine statistically valid approaches for representing these values.
- Assess the statistical distribution of constituent (Pu-239 ppb U, Np-237 ppb U, and Tc-99 ppb U) data.
- Based on the distribution determined, identify an approach to represent each dataset (i.e. for normal distributions, the mean of the dataset could be adequate, however, for non-normal distributions other more advanced approaches are required).



**TABLE ES-5B**  
**RMI REPRESENTATIVE CONSTITUENT VALUES BY DATA SUB-GROUP**

Sub-Group Number	Sub-Group (S/G) Title	Value for Pu-239 ppb U	Value for Np-237 ppb U	Value for Tc-99 ppb U
3	UF <sub>6</sub> Source Metal & Scrap	0.007	2.54	9.12
4	Normal U Products, Res & Metal Scrap	0.091	67.09	26.55
6A	UO <sub>3</sub> PUREX Source (A508)(Unblended)	2.884	388.97	8552.23
7A	A508 based Derbies	9.305	311.97	1721.00

WVDP UNH shipments to the FEMP are represented by a single data point located in the FEMP analytical data that represents a shipment from the WVDP.

**TABLE ES-5D**  
**WSSRAP REPRESENTATIVE CONSTITUENT VALUES BY DATA SUB-GROUP**

Sub-Group Number	Sub-Group (S/G) Title	Value for Pu-239 ppb U	Value for Np-237 ppb U	Value for Tc-99 ppb U
3	UF <sub>6</sub> Source Metal & Scrap	0.007	2.54	9.12
6A	UO <sub>3</sub> PUREX Source (A508)(Unblended)	2.884	388.97	8552.23

### Current Inventory of Recycled Uranium

The FEMP served as the DOE feed materials production center from the early 1950s through 1989. As discussed above, the FEMP received, shipped, and processed uranium products from 1961 through 1989 that used recycled uranium feed stocks containing constituents of concern. Since the curtailment of operations in 1989, the FEMP has been actively involved in DOE Environmental Management funded environmental restoration and waste management activities. These activities have included the completion of remedial investigation activities required for NPL listed sites, the completion of remedial design activities, and the initiation of remedial actions necessary to allow site closure. Two significant activities that have been ongoing since the termination of FEMP production operations are the management and disposition of low level and mixed radioactive wastes and the management and disposition of residual uranium materials (product) that could be useful to future DOE operational missions. As a result, the FEMP continues to have an inventory of both recycled uranium wastes and product that must be accounted for and evaluated to ascertain its contribution to the complex-wide mass balance.



Waste inventory data is shown in Table ES-1 (A-D). The data used to create the FEMP inventory Table ES-1A was derived using a report-specific query to obtain historical data (March 31, 1999) from the FEMP Sitewide Waste Information, Tracking and Reporting System (SWIFTS) database. For the purposes of the development of the recycled uranium report, the FEMP has assumed that the majority, essentially 100 percent, of the material and wastes resulting from production operations after 1961 contain recycled uranium and the constituents of concern.

Following the cessation of production operations at the FEMP, approximately 13,670 MTU of nuclear materials require disposition as either product (useable material) or as waste material. Since the process of dispositioning of this material began in 1989, approximately 11,000 MTU of nuclear materials have been dispositioned (included in shipment quantities). The FEMP recycled uranium inventory of nuclear materials remaining on-site as of March 31, 1999 is also included in Table ES-1A. Not included in this category are approximately 1,246 MTU of enriched, normal, and depleted non-recoverable residues that are considered as wastes and, as such, addressed in the FEMP waste inventory discussed above.

None of the other three sites covered by this report has remaining inventory.

#### **Location and Time Frames of Potential Worker Exposure**

The majority of processes at Fernald included steps that required manual handling of uranium compounds. Engineered safety systems were provided for worker protection, e.g. dust collectors for packaging stations and drum dumping stations. Monitoring programs were in place to assess the workers' exposures. The monitoring program had local administrative exposure limits, which were lower than the DOE exposure limits. The program included rotation of job assignments to prevent exceeding the local or DOE limits. Personnel protective equipment including respiratory protection was provided to workers to further reduce exposures. Prior to 1986, half face air purifying respirators were used predominately and from 1986 forward full-face air purifying respirators were the norm. Supplied air respirators were also available for use when conditions warranted.

The first recycle uranium was received in 1961, however, there may have been receipts from the gaseous diffusion plants that contained recycled uranium as early as 1955. During the campaign to process the Paducah flame tower ash in the mid-1980s, added precautions were taken. After 1985, work with this material was accomplished using disposable anti-contamination clothing and supplied air because of the known plutonium levels. Prior to 1985, records indicate that special precautions, e.g. airline respirators,



were adopted for at least some of the ash campaign. Based upon the National Institute of Occupational Safety and Health (NIOSH) records, approximately 7,300 individuals had worked at Fernald through 1990. Even with the programs described above, the entire worker population had a potential exposure to the recycled uranium.

Based on a qualitative assessment FEMP site processes with potential for airborne dusts discussed in detail in Appendix D, Attachment 1, the following summary table has been prepared for FEMP processes:

**TABLE ES-6A**  
**QUALITATIVE ASSESSMENT OF POTENTIAL AIRBORNE RECYCLED URANIUM DUSTS**

<u>Potential</u>	<u>Plant</u>	<u>Area</u>	<u>Materials</u>
High	5	Metal Reduction, Casting	UF <sub>4</sub> , MgF <sub>2</sub> , U, U <sub>3</sub> O <sub>8</sub> , Residues
	8	Feed Preparation Furnaces	U <sub>3</sub> O <sub>8</sub> , U, Residues
	4	Banks 7-9, Packaging Stations	UO <sub>3</sub> , UO <sub>2</sub> , UF <sub>4</sub>
Medium	2/3	Digestion, Denitration	Prepared Feed, U <sub>3</sub> O <sub>8</sub> , MgF <sub>2</sub>
	9	Reduction, Casting	UF <sub>4</sub> , MgF <sub>2</sub> , U, U <sub>3</sub> O <sub>8</sub> , Residues
	Pilot	Hex Reduction, Metal Operations	UF <sub>4</sub> , MgF <sub>2</sub> , U, U <sub>3</sub> O <sub>8</sub> , Residues
Low	6	Rolling Mill	U <sub>3</sub> O <sub>8</sub> , Metal Scraps Residues
	1	Milling	MgF <sub>2</sub> , U, U <sub>3</sub> O <sub>8</sub> , Residues

Processes at RMI, WVDP, and WSSRAP may also have presented similar potential for dusty conditions, however, less specific information or process knowledge was available to the project team. The RMI site scrap uranium oxidation process was the only process which handled uranium in a powdered form. WVDP processing resulted in a liquid uranium product, therefore reducing the likelihood of inhalation exposure. The vast majority of processing at the WSSRAP was of natural uranium, which is outside of the focus for this project.

#### **De Minimis Levels**

Based on the analytical data regimes developed in Appendix C and Appendix F, significant levels of constituent to uranium ratios exist in many of the categories presented. However, the vast majority of site receipts at all four sites were well within the de minimis values established for the Recycled Uranium Project by the DOE Mass Balance Project Project Plan. Since specific analytical data for each site



shipment and receipt is not available, the following process-knowledge-based assessment by site, indicates the probable material receipts for which the de minimis levels of recycle constituents are likely to have been exceeded. However, since internal site chemistry may have concentrated constituents and since, overall mass balance was based on final shipper/receiver data that evolved until late in the report development process, none of the streams, except those occurring prior to 1961, were eliminated from consideration by this report.

#### FEMP

Receipts at the FEMP above de minimis levels definitely included two specific campaign shipments from the Paducah GDP (Scrap Campaign and Ash Campaign – See Appendix E, Attachment 2). Other earlier and later GDP-source receipts at the FEMP, other than  $UF_6$ , are likely candidates for exceeding the de minimis levels set for this project. On occasion, receipts of A508  $UO_3$  from Hanford are expected to have exceeded de minimis quantities, since a number of FEMP analytical data points (Appendix C) for A508  $UO_3$  do exceed de minimis levels. Occurrence of these examples is, however, considered non-routine.

Shipments from the FEMP probably rarely exceeded de minimis levels, with the exception of metal shipped in the mid to late 1980s. Metal product from this time period was influenced by the large quantity of recycle constituents in the FEMP production stream from the Paducah Ash Campaign. Prior typical metal constituent levels would have been low, due to the number of blending steps inherent in the FEMP processes.

#### RMI

RMI shipments and receipts would have been similar, since no relevant chemical processing occurred at the site. If FEMP metal shipments to RMI exceeded de minimis levels on occasion, then resulting shipments from RMI to Hanford would be expected to parallel them.

#### WVDP

Since the WVDP UNH shipment analyses are largely unknown, there is no way to be certain in the application of the de minimis concept. One value identified in FEMP analytical data as representing a WVDP shipment to the FEMP results in a 3.95 ppb U for plutonium content. The expected isotopic level for the typical WVDP shipment to the FEMP could range from 0.86 % to perhaps 3 %. No isotopic level was reported for the data point and no statistical analysis is possible with only one data point, but there is a significant likelihood that de minimis levels were exceeded on occasion



## **WSSRAP**

With essentially no recycled uranium received or shipped and the small quantity of recycled uranium received and shipped very early in the history of uranium recycle, there is little likelihood of the de minimis level being exceeded at the WSSRAP site.

## **Location and Time Frame of Potential Environmental Releases**

The operational history of the four sites addressed within this report included activities that are known or suspected of causing reportable environmental releases of recycled uranium to the environment. Each of the sites, the FEMP, RMI, Weldon Spring, and West Valley, have ongoing DOE funded remediation and decommissioning activities in progress. As a result, the nature and extent of historical releases to the environment via airborne and liquid discharges are well quantified and thoroughly documented. Through qualitative evaluation of these environmental documents and the operational history of the sites with respect to recycled uranium, an evaluation of the activities that could have potentially caused reportable releases of recycled uranium to be constructed. Tables 8A and 8D provide a summary of known and potential environmental releases of recycled uranium from routine and non-routine operations at the FEMP and WSSRAP sites, respectively.

Data provided by RMI Environmental Services, Inc. indicated that the site historical operations had no significant environmental releases of recycled uranium or its constituents of concern.

The WVDP site was a source site, therefore, none of the environmental releases from the site would be considered recycled uranium under the definitions of this project.



**TABLE ES-7A**  
**FEMP SUMMARY OF DISCHARGES AND CONSTITUENT MASS**

Source	Discharge (MTU)	Pu (grams)	Np (grams)	Tc (grams)
Production (Routine)				
Dust Collectors	19.4	0.1	7.5	165.9
Wet Scrubbers	21.6	0.1	8.4	184.7
Gulping Operations	25.7	0.1	10.0	219.8
Other	6.4	0.0	2.5	54.7
Production (Non-Routine)				
Pilot Plant	1.5	0.0	0.1	0.3
Plant 2/3	22.6	0.5	23.6	63.0
Other	2.1	0.0	0.8	18.0
Non-Production (Routine)				
Incinerator	3.1	0.1	3.2	8.6
Storage	1.0	0.1	4.0	4.1
Other	0.3	0.0	0.4	0.7
Liquid Discharge				
Great Miami River	55.4	0.9	73.6	132.9
Paddy's Run	11.1	0.2	14.7	26.6
Total	170.0	2.1	148.8	879.3

**TABLE ES-7D**  
**WSSRAP SUMMARY OF DISCHARGES AND CONSTITUENT MASS**

Source	Discharge (MTU)	Pu (grams)	Np (grams)	Tc (grams)
Production (Routine)				
Stacks	45.0	0.0	3.0	1.2
Non-Production (Routine)				
Raffinate Pits	155.3	0.0	10.4	4.1
Liquid Discharge				
Sewers	26.7	0.0	1.9	0.8
Total	227.0	0.0	15.3	6.1